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Forest Pest Management
Pacific Northwest Region

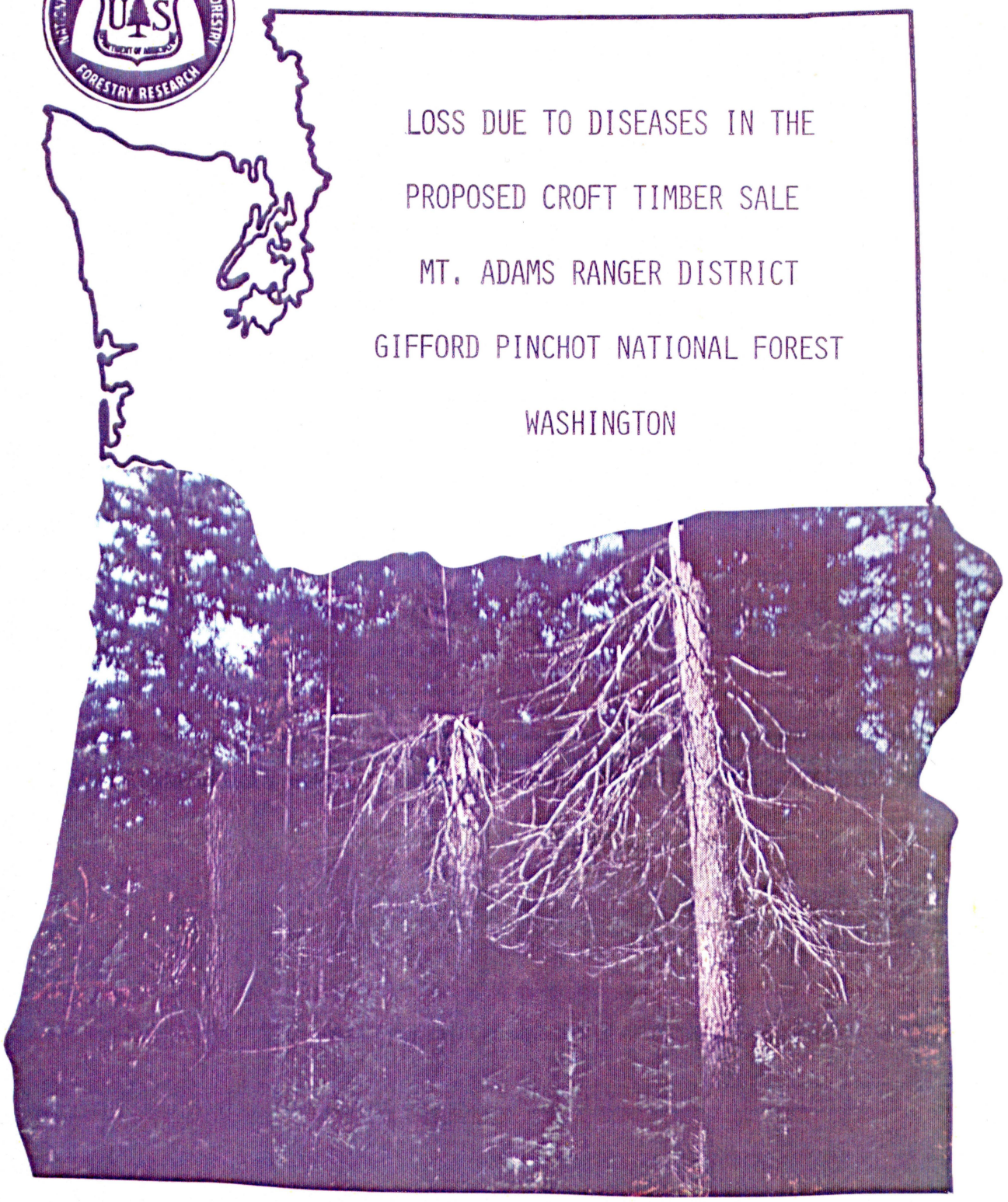
LOSS DUE TO DISEASES IN THE

PROPOSED CROFT TIMBER SALE

MT. ADAMS RANGER DISTRICT

GIFFORD PINCHOT NATIONAL FOREST

WASHINGTON



1981

LOSS DUE TO DISEASES IN THE PROPOSED CROFT TIMBER SALE, MT. ADAMS RANGER DISTRICT, GIFFORD PINCHOT NATIONAL FOREST, WASHINGTON

By

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Introduction

Root diseases cause severe damage in many forested areas of the Pacific Northwest. Damage occurs as tree mortality and growth loss in living infected trees. Many stands experience significant and long-lasting reductions in productivity as a result of continuing damage.

The two most common root diseases in the grand/white fir type in the Region are Armillaria root rot caused by *Armillaria mellea* (Vahl ex Fr.) Quel. and laminated root rot caused by *Phellinus weirii* (Murr.) Gilbertson. Wood volume losses as high as 70 ft^3/acre/year and 85 ft^3/acre/year have been reported in grand/white fir types in Oregon, caused by *A. mellea* and *P. weirii*, respectively (Filip 1980, Goheen 1980).

The mycelia of *A. mellea* and *P. weirii* spread from tree to tree via root contacts and grafts. Black, shoestring-like structures called rhizomorphs produced by *A. mellea* grow directly through soil to act as a principal method of spread for this pathogen. These pathogens commonly survive in old-growth stumps of the previous overstory. Large infested stumps can serve as food bases for these fungi for several decades. When the roots of newly established trees come into contact with this inoculum, they can become infected.

This report documents the results of a survey on an area located within the Mt. Adams Ranger District, Gifford Pinchot National Forest, 3 miles south of the Mt. Adams Wilderness (T. 7 N., R. 10 E., Secs. 8 and 9, W. M., Figure 1). This area is a 150-acre portion of the proposed Croft Timber Sale. On October 15, 1980, the Mt. Adams District requested that a pathologist from the Forest Pest Management section of the Regional Office evaluate the disease situation in this area. Following preliminary reconnaissance, Pathologist Gregory Filip recommended to the District in a letter dated October 28, 1980, that a disease survey of the area be done to determine incidence of insects, diseases, and associated tree mortality.

Objectives

Objectives of this evaluation were to:

1. Determine per acre losses of trees, basal area, and volume due to root diseases and other causes of tree mortality over a 150-acre area.

2. Determine distribution and intensity of root diseases and dwarf mistletoe over the area.

3. Develop management alternatives to reduce present and future mortality caused by diseases and insects.

Methods

Plot Establishment

A line-point sampling method was used. Variable radius plots (BAF 40) were established every two chains along lines placed five chains apart across the survey area. Data were collected for all trees on every fifth plot (measure plots) along with a basal area count. On all other plots (count plots), data were collected on root diseased trees only, along with a basal

area count of all trees on the plot. Count plots with no evidence of root diseases were recorded as healthy. Only trees greater than or equal to 5.0 in. DBH were inspected and recorded.

Data Collection

The following data were recorded for each plot tree: 1) species, 2) DBH, (approximated for stumps of harvested trees), 3) total height, 4) condition (living, dead, standing, down), and 5) cause of infection or mortality. Trees or stumps with less than half of their circumference at the root collar covered by intact bark were considered to have been dead for more than 20 years and were not recorded.

Dead or dying trees exhibiting crown symptoms of root disease (chlorosis, reduced growth, reduced needle length, or fading) were inspected for root pathogens. These trees, along with adjacent stumps and symptomless trees, were examined by limited excavation and dissection of major roots and removing small portions of the bark at the root collar.

Identity of root pathogens was determined from specific root or root collar indicators. Laminated root rot was diagnosed by the presence of ectotrophic mycelium on the outer surface of exposed roots or by characteristic pitted and laminated wood decay (Figure 2), along with setal hyphae in old, dead material. Armillaria root rot was diagnosed by the presence of cream-colored mycelial fans beneath the bark (Figure 3), presence of black, stringy rhizomorphs on outer bark surfaces, or by yellow, stringy decay in old, dead material. Some decayed wood not readily identified in the field was returned to the laboratory for tissue culturing and subsequent identification.

From the collected data, mean basal area, number of trees, and volume (M cubic feet and M board feet) per acre were calculated by tree species, DBH class, and condition using the Region 6, V-Plot Computer Program. Plot information was used to prepare a disease distribution map.

Results

Stand Composition

Grand fir *(Abies grandis)* was the predominant tree species in the area surveyed. Of an average 187.4 trees per acre greater than or equal to 5.0 inches DBH, 88.6 (47.3%) were grand fir. Trees per acre data for other species were: Douglas-fir (*Pseudotsuga menziesii*), 21.9 (11.7%); white pine *(Pinus monticola)*, 17.4 (9.3%); noble fir *(A. procera)* 17.1 (9.1%); western red cedar *(Thuja plicata)* 8.2 (4.4%); and 34.5 (18.4%) were other species, which included western hemlock *(Tsuga heterophylla)*, larch *(Larix occidentalis)*, ponderosa pine *(P. ponderosa)*, and Engelmann spruce *(Picea engelmannii)*. The average total board-feet volume per acre was 58.8M. Average board-feet volumes per acre by species were: grand fir, 24.6M (41%); Douglas-fir, 20.5M (35%); noble fir, 5.7M (10%); red cedar, 4.4M (7%); white pine, 2.7M (5%); and other species, 1.4M (2%) (Table 1).

Root Disease-Caused Mortality by Plot Basis

Approximately 150 acres were surveyed systematically using 155 plots (about 1.0 plot per acre). Of these, 65 plots (42%) contained one or more trees infected by root pathogens (Figure 4). This is probably an underestimate since not all trees or entire root systems were examined.

Mortality Agents

An average of 25.2 trees (13%) of the total of 187.5 trees per acre representing 12% of the basal area, 12% of the cubic-foot volume and 8% of the board-foot volume were found to be infected by root pathogens (Table 1). Most infection was by *P. weirii* (Table 2). Infection by *A. mellea* was encountered to a lesser degree, both by itself and on trees also infected by *P. weirii*.

Other diseases and insect problems encountered and recorded during the survey included Douglas-fir dwarf mistletoe *(Arceuthobium douglasii)*, white pine blister rust (*Cronartium ribicola*), and mountain pine beetle *(Dendroctonus ponderosae)*-caused mortality in white pine.

Conks of the Indian paint fungus *(Echinodontium tinctorium)*, a serious heart rotting agent, were observed on a very few hemlock.

Some fir engraver *(Scolytus ventralis)*-caused mortality was found to be associated with root diseases.

Dwarf mistletoe was the most serious damaging agent other than root diseases. It was found in 3 percent of the stems, representing 10 percent of the basal area, 10 percent of the cubic-foot volume, and 10 percent of the board-foot volume (Table 1).

Disease Summary by Species

1. Grand fir

Grand fir was found to be the species most seriously affected by root diseases. Most infection and mortality was caused by *P. weirii*. Grand fir is classified as highly susceptible to *P. weirii* (Hadfield and Johnson 1977). Infection and mortality caused by *A. mellea* was found less frequently. Infection and mortality also was observed involving both of these pathogens together on individual trees (Table 2). Root diseases account for mortality and infection in 20.7 (23%) of the grand fir stems per acre. These diseased trees contain 20 percent of the basal area, 20 percent of the cubic-foot volume, and 19 percent of the board-foot volume (Table 1) of grand fir. None of the grand firs were infected by dwarf mistletoe.

2. Douglas-fir

Most Douglas-fir in the surveyed area was large old-growth. Incidence of root infection and tree mortality was somewhat less than in grand fir. Evidence of root diseases was found on 2.6 (12%) of the stems per acre which represented 9 percent of the basal area, and 8 percent of the cubic- and board-foot volume (Table 1) of Douglas-fir.

The most damaging root disease of Douglas-fir was laminated root rot caused by *P. weirii*. Douglas-fir is classified as highly susceptible to *P. weirii* (Hadfield and Johnson 1977). This pathogen was found causing infection and mortality in 70 percent of the total root-diseased Douglas-fir basal area (Table 2). Armillaria root rot was found in 26 percent of the diseased basal area. The remaining 4 percent was infected with both pathogens concurrently.

Douglas-fir dwarf mistletoe *(A. douglasii)* was found to be a serious problem, infecting 5.2 (24%) trees per acre. This represented 28 percent of the basal area and 27 percent of the cubic- and board-foot volume (Table 1) of Douglas-fir. This disease also appeared to be the primary cause of mortality in some of the larger diameter Douglas-fir. Infection and mortality occurred mostly in larger diameter trees (Table 3).

3. Noble fir

All the noble fir mortality encountered was caused by *P. weirii*. Of the total 17.1 stems per acre, 1.6 (9%) was either dead or dying due to effects of this pathogen. This represented 9 percent of the basal area and 8 percent of the cubic- and board-foot volume (Table 1) of the noble fir.

No other diseases were found affecting noble fir. Although there is little data concerning the susceptibility of noble fir to *P. weirii*, it is believed to be intermediately susceptible like larch and spruce.

4. White pine

Western white pine was affected by several insects and diseases. Root diseases caused by either *P. weirii* or *A. mellea* were found on 0.2 (1%) of the stems per acre (Table 2). White pine is classified as tolerant to *P. weirii* (Hadfield and Johnson 1977). Mostly larger diameter trees were infected, representing 7 percent of the basal area and 7 percent of the board-foot volume (Table 1) of the white pine.

White pine blister rust was the most serious disease affecting this species. Blister rust had infected and/or killed 15.9 (91%) of the stems per acre. The smaller diameter classes were infected most severely. Dead and living infected trees made up 35 percent of the white pine basal area, 31 percent of the cubic-foot volume, and 25 percent of the board-foot volume (Table 1).

Mountain pine beetles *(D. ponderosae)* were found to have caused considerable mortality in the larger diameter classes. Beetle killed trees represented 11 percent of the white pine basal area, 13 percent of the cubic-foot volume, and 14 percent of the board-foot volume (Table 1).

Conclusions and Recommendations

Several pest problems reducing productivity occur on the proposed Croft Timber Sale area. These are root diseases, Douglas-fir dwarf mistletoe, blister rust, and bark beetles. Silvicultural treatments are needed in the overmature stands where losses are heaviest.

Root rots, especially that caused by *P. weirii*, are the most serious problems. Root diseases are difficult to manage since they are hard to detect and persist on the site following host death or timber harvesting. Successful management involves favoring species less susceptible to infection and mortality or removing stumps following harvest and replanting with susceptible species adapted to the site. Usually, the former is the most economical alternative.

Douglas-fir dwarf mistletoe is a somewhat easier pathogen to manage. It is easier to detect, spreads slowly, and dies with its host. Silvicultural treatments involve removing infected overstory trees to prevent spread to susceptible species of trees of the next rotation or favoring tree species not susceptible to infection.

Bark beetles and blister rust are causing serious losses in the white pine component. The greatest impact in the smaller diameter trees is by blister rust. Bark beetles are a serious problem in the larger, overmature pine. Management for this valuable species requires planting with blister rust-resistant stock, managing stocking levels, and harvesting on shorter rotations.

The following management alternatives have been formulated for the Croft Timber Sale area based on disease and insect losses presently occurring. Criteria for developing alternatives are based on current knowledge of disease management aimed at minimizing present and future losses. Alternatives are presented in increasing order of cost and effectiveness.

1. Defer Treatment

Losses due to root disease-caused mortality should average at least 1.3 trees per acre each year. This represents an annual per acre loss due to mortality of 62 ft^3 or 348 board-feet of timber. This does not include growth loss of infected trees and cull due to butt rot. White pine mortality due to blister rust and bark beetles will continue. Mortality and growth loss from dwarf mistletoe will accelerate.

These stands are experiencing reductions in yield due to overmaturity and the high incidence of disease- and insect-induced mortality. Deferring treatment will result in continued losses.

2. Salvage Option

Entering these stands periodically at several year intervals will allow harvest of merchantable dead, dying, and high-risk trees. Managing against dwarf mistletoe will be possible with this alternative by removing infected overstory Douglas-fir. White pine mortality could be periodically harvested along with root rot trees.

This alternative will do nothing to reduce incidence of root rots, particularly that of laminated root rot. Losses can be expected to increase in the future as susceptible regeneration becomes infected and root rot centers increase in size.

3. Seed Tree or Shelterwood System

These silvicultural techniques involve leaving suitable trees to provide shelter and/or seed following harvest and site treatment. The likelihood of success in implementing this alternative is limited by the availability of proper leave trees. In the Croft Sale area, adequate stocking of species resistant to the several diseases is not uniform. If this silvicultural treatment is used, a number of small areas of 1 or more acres would be left without adequate numbers of desirable leave trees. Considering market value and root disease resistance, preferable leave trees include western larch, ponderosa pine, and blister rust-resistant white pine. In portions of stands where laminated root rot is not present, dwarf mistletoe-free Douglas-fir would also be a preferred leave tree. A careful job of leave tree selection would be required based on species, vigor, lack of dwarf mistletoe, and presence or absence of root rots on the site. Dwarf mistletoe-infected Douglas-fir could be left if the leave trees are removed before the Douglas-fir understory reaches 10 years old or 3 feet tall.

White pine regeneration would be subject to serious blister rust-caused mortality unless progeny is from resistant stock. It is possible to rate the blister rust hazard of sites. Hazard rating would allow the level of resistance needed to be matched to the site hazard.

4. Clearcutting

This alternative involves cutting blocks of timber in areas with the highest disease occurrence, especially root rots. Site treatment by dozer piling and burning could be accomplished easily along with planting of preferred stock. Using this silvicultural system, the present disease situation could be managed.

Root rot-caused losses in future rotations can be minimized by planting to full stocking valuable tree species identified as being resistant (ponderosa pine), tolerant (western white pine), or intermediately susceptible (Englemann spruce, western larch). In the general Croft Sale area there is at least one plantation fully stocked with ponderosa pine planted following a clearcut harvest. This plantation appears to be healthy and is growing quite well. Due to the resistant nature of ponderosa pine to laminated root rot and the availability of seed from stands within and around the Sale area, this would be the preferred species for replanting.

Dwarf mistletoe would be eliminated within harvest units. Mountain pine beetle mortality in subsequent rotations can be minimized by keeping stands thrifty, keeping basal area below 120 ft^2/acre for ponderosa pine and white pine, and harvesting upon maturity.

5. Seed Tree or Clearcut Systems with Stump Removal

This silvicultural system would be the most expensive, yet allow the greatest flexibility in regenerating since any species can be replanted safely. The gentle topography found within most of the Sale area would permit large equipment to remove stumps (Roth, et al, 1977).

In clearcut units, root rot centers should be located and flagged immediately following felling and yarding. In seed tree units, centers should be located prior to marking leave trees. This will facilitate selection of leave trees. Healthy, yet susceptible trees can be left if they will not seed within 100 feet of a disease center. Interplanting with disease-resistant stock is a possibility where large openings occur after susceptible trees are removed. Funds from FPM are available to implement this alternative on a limited basis to serve as a demonstration of current control procedures.

References Cited

Filip, G. M.
1980. Timber volume loss due to root disease in the Wagon Sale Area, Sisters Ranger District, Deschutes National Forest, Oregon. Forest Insect and Disease Management, Pacific Northwest Region, USDA Forest Service, Portland, Oregon. 30 pp.

Goheen, D. J.
1980. Root disease surveys of the Hyatt Lake Rehab and Howard Willow Sales, Medford District, Bureau of Land Management. Forest Insect and Disease Management, Pacific Northwest Region, USDA Forest Service, Portland, Oregon. 8 pp.

Hadfield, J. S., and D. W. Johnson
1977. Laminated root rot, a guide for reducing and preventing losses in Oregon and Washington Forests. Forest Pest Management, Pacific Northwest Region, USDA Forest Service, Portland, Oregon. 16 pp.

Roth, L. F., C. G. Shaw III, and L. Rolph
1977. Marking ponderosa pine to combine commercial thinning and control of Armillaria root rot. Journal of Forestry 77:644-647

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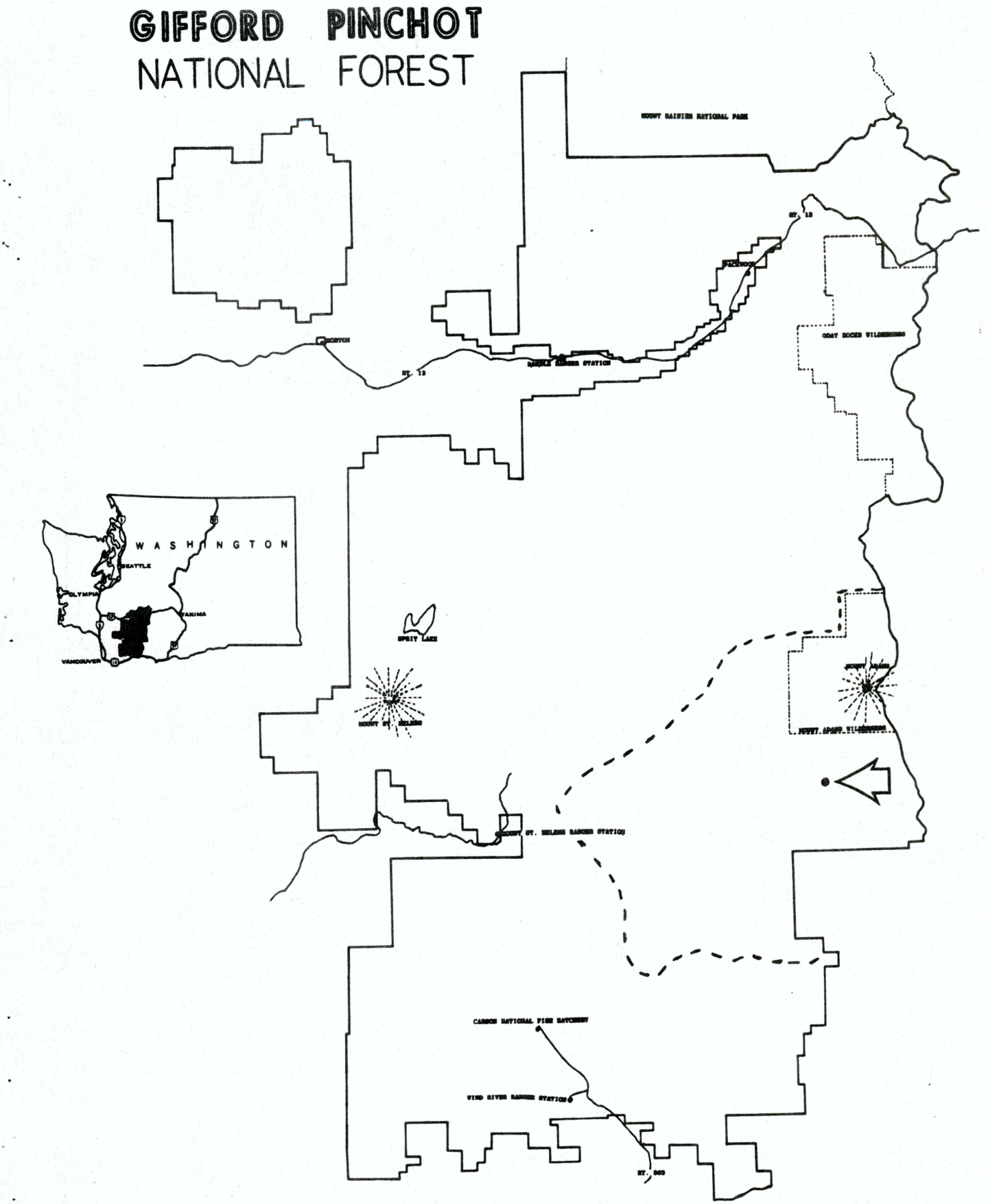

FIGURE 1. Map depicting area surveyed (arrow). Dotted line indicates northern, western and southern boundaries of the Mt. Adams Ranger District.

FIGURE 2. Laminated decay in Douglas-fir caused by *Phellinus weirii*

FIGURE 3. Mycelial fans of *Armillaria mellea* beneath the bark of an infected grand fir

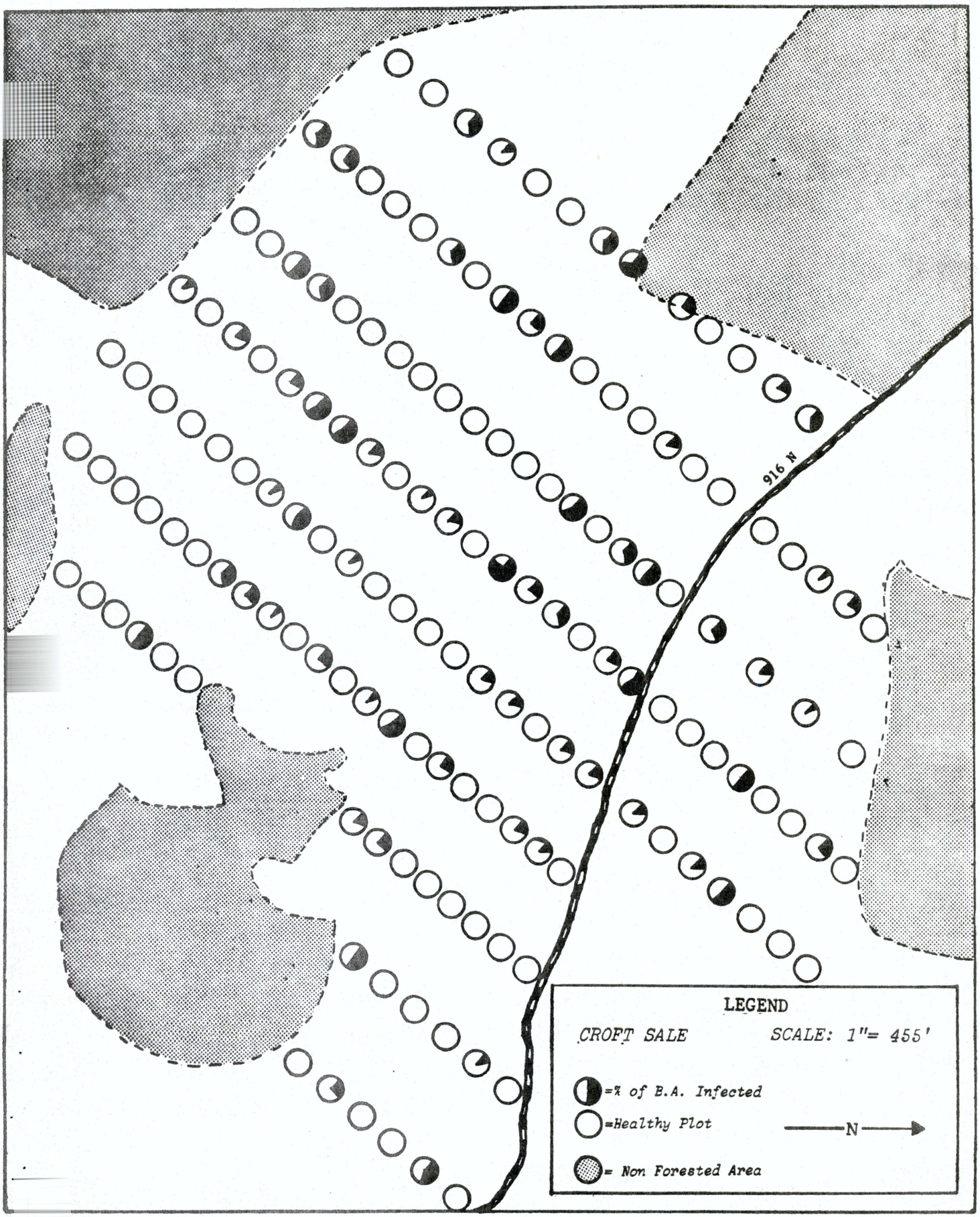

FIGURE 4. Map of survey area showing plots infected by root diseases.

Table 1—Relative Frequencies of Diseases and Bark Beetles by Tree Species

Species		Total	Non-Root Diseased	Root Diseased				Indian[a] Paint	Blister[a] Rust	Dwarf[a] Mistletoe	Bark[a] Beetles
				Live	Dead	Harvested	Total				
Grand Fir	T/Ac	88.6	67.8	0.7	20.1	-0-	20.8 (23)[b]	-0-	-0-	-0-	3.8
	BA/Ac	115.1	92.0	1.3	21.8	-0-	23.1 (20)	-0-	-0-	-0-	1.3
	MCF/Ac	4.2802	3.4306	0.0443	0.8053	-0-	0.8496 (20)	-0-	-0-	-0-	0.0351
	MBF/Ac	24.144	19.47	0.2450	4.429	-0-	4.674 (19)	-0-	-0-	-0-	<.001
Douglas-fir	T/Ac	21.9	19.3	0.4	2.1	0.1	2.6 (12)	-0-	-0-	5.2 (24)	-0-
	BA/Ac	90.8	82.7	0.5	7.3	0.3	8.1 (9)	-0-	-0-	25.3 (28)	-0-
	MCF/Ac	3.3489	3.0669	0.016	0.257	0.009	0.2820 (8)	-0-	-0-	0.9009 (27)	-0-
	MBF/Ac	20.4756	18.815	0.0827	1.5273	0.0506	1.6606 (8)	-0-	-0-	5.5212 (27)	-0-
Noble fir	T/Ac	17.1	15.5	0.2	1.4	-0-	1.6 (9)	-0-	-0-	-0-	-0-
	BA/Ac	27.7	25.3	0.5	1.9	-0-	2.4 (9)	-0-	-0-	-0-	-0-
	MCF/Ac	1.0337	0.9513	0.0173	0.0651	-0-	0.0824 (8)	-0-	-0-	-0-	-0-
	MBF/Ac	5.7205	5.2759	.0969	0.3477	-0-	0.4446 (8)	-0-	-0-	-0-	-0-
Red Cedar	T/Ac	8.2	8.2	-0-	-0-	-0-	0.0	-0-	-0-	-0-	-0-
	BA/Ac	22.7	22.7	-0-	-0-	-0-	0.0	-0-	-0-	-0-	-0-
	MCF/Ac	0.7537	0.7537	-0-	-0-	-0-	0.0	-0-	-0-	-0-	-0-
	MBF/Ac	4.419	4.419	-0-	-0-	-0-	0.0	-0-	-0-	-0-	-0-
Other[c]	T/Ac	34.5	34.4	-0-	0.1	-0-	0.1 (<1)	.4 (1)	-0-	.3	-0-
	BA/Ac	9.7	9.4	-0-	0.3	-0-	0.3 (3)	1.4 (14)	-0-	1.3	-0-
	MCF/Ac	0.2737	0.2616	-0-	0.0121	-0-	0.0121 (4)	.0472 (17)	-0-	.0642	-0-
	MBF/Ac	1.3564	1.2833	-0-	0.0731	-0-	0.0731 (5)	.276 (20)	-0-	.4065	-0-
White Pine	T/Ac	17.4	17.2	-0-	0.2	-0-	0.2 (1)	-0-	15.9 (91)	-0-	0.3 (2)
	BA/Ac	11.5	10.7	-0-	0.8	-0-	0.8 (7)	-0-	4.0 (35)	-0-	1.3 (11)
	MCF/Ac	0.4653	0.4352	-0-	0.031	-0-	0.0301 (6)	-0-	0.1456 (31)	-0-	0.0604(13)
	MBF/Ac	2.7019	2.52	-0-	0.1819	-0-	0.1819 (7)	-0-	0.6640 (25)	-0-	0.3799(14)
Grand Total	T/Ac	187.5	162.3	1.3	23.8	.1	25.2 (13)	0.4 (<1)	15.9 (8)	5.5 (3)	4.1
	BA/Ac	277.3	242.7	2.4	31.9	.3	34.6 (12)	1.3 (<1)	4.0 (1)	26.6 (10)	2.7
	MCF/Ac	10.1556	8.8994	0.0776	1.1696	.009	1.2562 (12)	0.0472 (<1)	0.1456 (1)	0.9651 (10)	0.0955
	MBF/Ac	58.8177	51.7835	0.4246	6.559	0.0506	7.0342 (12)	0.2760 (<1)	0.6640 (1)	5.9277 (10)	0.3799

a/ Included in non-root diseased.
b/ Number in parentheses are percent of total.
c/ Includes: Englemann spruce, western hemlock, ponderosa pine, western larch.

Table 2--Relative Frequencies of Root Diseases by Tree Species and Pathogen

Species		Total Root Diseased	*Phellinus weirii*	*Armillaria mellea*	*Phellinus* + *Armillaria*
Grand Fir	T/Ac	20.7	18.5	1.6	0.6
	BA/Ac	22.8	17.2	3.5	2.1
	MCF/Ac	0.8375	0.6045	0.1374	0.0956
	MBF/Ac	4.6009	3.2186	0.7905	0.5918
Douglas-fir	T/Ac	2.6	1.4	1.1	0.1
	BA/Ac	8.1	5.7	2.1	0.3
	MCF/Ac	0.282	0.2004	0.0731	0.0085
	MBF/Ac	1.6606	1.2128	0.4030	0.0448
Noble fir	T/Ac	1.6	1.6	-0-	-0-
	BA/Ac	2.4	2.4	-0-	-0-
	MCF/Ac	0.0824	0.0824	-0-	-0-
	MBF/Ac	0.4446	0.4446	-0-	-0-
Red cedar	T/Ac	-0-	-0-	-0-	-0-
	BA/Ac	-0-	-0-	-0-	-0-
	MCF/Ac	-0-	-0-	-0-	-0-
	MBF/Ac	-0-	-0-	-0-	-0-
ther[b]	T/Ac	0.1	-0-	0.1	-0-
	BA/Ac	0.3	-0-	0.3	-0-
	MCF/Ac	0.0121	-0-	0.0121	-0-
	MBF/Ac	0.0731	-0-	0.0731	-0-
White pine	T/Ac	0.2	0.1	0.1	-0-
	BA/Ac	0.8	0.3	0.5	-0-
	MCF/Ac	0.0301	0.0098	0.0203	-0-
	MBF/Ac	0.1819	0.0601	0.1218	-0-
Grand total	T/Ac	25.1	21.4 (85)[a]	2.9 (12)	0.8 (3)
	BA/Ac	34.4	25.6 (74)	6.4 (19)	2.4 (7)
	MCF/Ac	1.2441	0.8971 (72)	0.2429 (20)	0.1041 (8)
	MBF/Ac	6.9612	4.9361 (71)	1.3885 (20)	0.6366 (9)

a/ Number in parentheses are percent of total

b/ Includes:
Englemann spruce
western hemlock
ponderosa pine
western larch

Table 3—Relative Frequencies of Diseases and Bark Beetles by Tree Size Classes

DBH Class (in.)	Total	Non Root Diseased	Root-Diseased				Indian[a] Paint	Blister[a] Rust	Dwarf[a] Mistletoe	Bark[a] Beetles
			Live	Dead	Harvested	Total	Live and Dead	Live and Dead	Live and Dead	Dead
	TREES PER ACRE									
4	67.3	61.1	-0-	6.2	-0-	6.2 (9)[b]	-0-	15.3 (23)	-0-	-0-
8	16.2	11.5	-0-	4.7	-0-	4.7 (29)	-0-	-0-	-0-	3.8
12	31.6	27.2	0.7	3.7	-0-	4.4 (14)	-0-	-0-	-0-	-0-
16	17.2	14.3	0.2	2.7	-0-	2.9 (17)	-0-	-0-	1.9 (11)	-0-
20	16.5	14.1	0.1	2.3	-0-	2.4 (15)	-0-	-0-	0.6 (4)	-0-
24	15.7	13.6	0.2	1.8	0.1	2.1 (13)	0.4 (3)	0.4 (3)	0.8 (5)	-0-
28	10.7	9.0	0.1	1.6	-0-	1.7 (16)	-0-	-0-	1.9 (18)	-0-
32	5.9	5.5	-0-	0.4	-0-	0.4 (7)	-0-	-0-	1.2 (20)	-0-
36	3.5	3.2	-0-	0.3	-0-	0.3 (8)	-0-	0.2 (6)	0.6 (17)	-0-
40	2.2	2.1	-0-	0.1	-0-	0.1 (5)	-0-	-0-	0.5 (23)	-0-
44	0.6	0.6	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
48	0.1	0.1	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total	187.5	162.3	1.3 (1)	23.8 (13)	0.1 (<1)	25.2 (13)	0.4 (<1)	15.9 (8)	7.5 (4)	3.8

a/ Included in non-root diseased

b/ Numbers in parentheses are percent of total